COVER SHEET

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Examining preservice teachers' involvement in online science education

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Abstract

In various western countries, preservice teachers are electing to learn how to teach primary science education though online coursework. Debate arises over the quality of online coursework to deliver adequate knowledge and skills for teaching primary science and how to improve online pedagogy. Using a posttest design, responses from 26 third-year preservice teachers from the same university were analysed after involvement in an online primary science pedagogy course. A 34-item survey, which was linked to the course outcomes (constructs) and multiple indicators, aimed to measure the preservice teachers' perceptions of their development towards becoming primary science teachers. Results indicated that although online science education courses may assist preservice teachers' perceptions of learning how to teach primary science education, understanding children's manipulative skills for learning about science will require further pedagogical improvement. Online preservice teacher education programs may be enhanced by assessing preservice teachers' ability to implement education reform measures and addressing relevant issues with enhanced online pedagogical practices.

Many reform programs have been implemented to assist the facilitation of science education in primary schools (Harlen, 1999; Jarvis, McKeon, Coates, & Vause, 2001). In Australia, programs have been devised to target professional development of teachers. Despite these efforts, the quality of science education requires considerable development in Australia (Goodrum, Hackling, & Rennie, 2001). Reform efforts need to be targeted at the earliest stages for teaching. Indeed, preservice teachers are generally interested in developing pedagogical practices in science education (Rice & Roychoudhury, 2003). Hence, a way forward for advancing science education reform processes must include preservice teacher education (Watters & Ginns, 2000).

Preparing preservice teachers to teach science education

National and international standards have been devised for teaching science education. For example, the Australian National Science Standard Committee (ANSSC, 2002) and the American Association for the Advancement of Science (AAAS, 1993) advocate the development of teachers' pedagogical knowledge as a way for implementing current science education practices. Universities involved in preservice teacher education also aim to advance science education by designing coursework based on current theories and practices for teaching science education. The development of preservice teachers' skills for teaching science requires scaffolding with focused attention on the acquisition of pedagogical knowledge (Abell & Bryan, 1999; Briscoe & Peters, 1997; Coates, Jarvis, McKeon, & Vause, 1998; Hudson, Skamp, & Brooks, 2005), which facilitates students' learning of science concepts. Pedagogical knowledge for educating preservice primary science teachers includes understanding:

1. Theoretical underpinnings used for developing a science curriculum.
2. The development of children's science concepts, scientific reasoning abilities,

manipulative skills, and attitudes.

3. Effective planning for science teaching and learning.
4. The implementation of effective science teaching practices, including successful management of the learning environment.

To be prepared for primary science teaching, preservice teachers need to analyse and understand current theories that underpin a science curriculum (Fleer & Hardy, 2001). Constructivism is one such suite of epistemologies advocated for use in primary science teaching with consideration of prior knowledge and students' misconceptions (Skamp, 2004). The development of a science syllabus generally draws upon current theories (e.g., Board of Studies, 1999; Queensland School Curriculum Council, 1999); hence online preservice teacher education needs to include current theories and make the connections to practice as advocated by the presiding syllabus.

National reform agendas (ANSSC, 2002; AAAS, 1993) advocate inquiry-based learning with equal opportunities for all students to develop scientific literacy. This requires preservice teachers understanding students' prior knowledge (Skamp, 2004), misconceptions or alternative conceptions (Wandersee, Mintzes, & Novak, 1994) and manipulative skills and attitudes (Fleer & Hardy, 2001) in order to facilitate appropriate and relevant science lessons (Abruscato, 2004). Preservice teachers need to have a repertoire of primary science teaching approaches (e.g., inquiry, interactive, and discovery approaches; see Fleer & Hardy, 2001) and successful science teaching models (e.g., Bybee's Five Es [1997] and Gunstone and White's [1981] predict-observe-explain [POE] model). "Articulating viewpoints about theories, approaches, and models for teaching science may demonstrate a preservice teacher's propensity for developing effective primary science education lessons" (Hudson & Ginns, 2005, p. 4).

Planning for effective science education is paramount (Jarvis et al., 2001). A theoretically based rationale for teaching science, a scope and sequence for providing long-term science topics, integrating science with other key learning areas (Hudson, 2000), and the use of concept maps that provide visual connections to other key learning areas (Fleer & Hardy, 2001) aid in the planning process. In addition, outcomes-based education for planning, implementing, and assessing primary science education provides a stronger focus on students' achievements (e.g., AAAS, 1993; Board of Studies, 1999; Queensland School Curriculum Council, 1999). This involves developing in preservice teachers appropriate teaching strategies (Tobin & Fraser, 1990), preparation of resources (Rosaen & Lindquist, 1992), classroom management strategies (Feiman-Nemser & Parker, 1992), questioning techniques (Fleer & Hardy, 2001), content knowledge (Skamp, 2004), and effective assessment and evaluation procedures (Corcoran & Andrew, 1988; Jarvis et al., 2001). Preservice teachers also need to develop critical self-reflection in order to enhance their pedagogical practices (Schön, 1987). Addressing ethical and attitudinal issues can also aim at catering for all students regardless of ability (AAAS, 1993; Fleer & Hardy, 2001).

Assessments for this study's online science education course

Three assessments were aligned to this online science education course. The first assessment required students to design a science unit of work. Online materials supported the students' learning for developing a rationale for teaching a science unit of work. This also included facilitating potential school and class scenarios, science content significance, key science concepts, theoretical designs for teaching science, science teaching strategies, science syllabus links and methods of assessing and evaluating a science unit of work. Students were also provided with examples of science unit overviews, integrated overviews, science lesson plans, and assessment and evaluation proformas, which they needed to include in their science unit of work.

The second assessment involved intellectual participation in an online discussion forum. Students were placed into discussion forum groups with five or six to each group. Each week questions or statements were posted online for discussion between members in each group. The questions and statements were based around four discussion forum assessment criteria, namely, that the students were able to: Articulate the theoretical base of science curriculum development in an informative, insightful and logical way; Demonstrate a clear understanding of the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes; Justify and demonstrate how to apply appropriate instructional strategies including management of the learning environment and selection of activities and resources for the teaching of science; and, Provide sound arguments and clear evidence with linkages to the readings, lectures, tutorials, and websites provided in this unit.

The third assessment required students to provide a portfolio that also focused on the above four discussion forum criteria. However, it required students to provide appendices on key literature links to these criteria. In addition, students needed to construct at least ten annotated bibliographies on one or more key science-related areas (e.g., sustainable living education, leadership in science education, innovative practices in science, professional development for science teaching). All three assessments required students to present links to current literature while adhering to APA referencing style with attention to logical structure, clear expression, and correct spelling and grammar.

Aim of this study

In order to determine the extent of achieving fundamental elements for implementing science education reform, universities need to include specific assessments of preservice teachers' capabilities for teaching primary science. Identifying preservice teachers' strengths and weaknesses for teaching science may enable science educators to developed more appropriate programs and may also determine the extent of achieving science education reforms. Hence, this study aimed to assess third-year preservice teachers' perceptions of their pedagogical knowledge for teaching primary science after involvement in an online science education course that may be associated with reform directions. In addition, preservice teachers' evaluation of the course may provide future directions for improving online education.

Data collection methods and analysis

A posttest survey instrument was used to examine 26 third-year preservice teachers' perceptions of their primary science pedagogical development at the conclusion of an online science pedagogy course at one Australian university. This sample (n=26) represented a 32% response rate of the total cohort of third-year preservice teachers who completed an online science education course of one-semester duration. Topics included: Constructivism; The social nature of learning; Conceptual change; Problem-based inquiry; Instructional designs; and Designing science units of work. The 34 survey items had a five-part Likert scale, that is, "strongly disagree", "disagree", "uncertain", "agree", and "strongly agree". Scoring was accomplished by assigning a score of one to items receiving a "strongly disagree" response, a score of two for "disagree" and so on through the five response categories.

The statements on the survey sought participants' perceptions of their development towards becoming primary science teachers. These statements (items) represented relevant indicators of four theoretical course outcomes (constructs), which are also indicated in the literature (e.g., Fleer & Hardy, 2001; Skamp, 2004). For example, the course outcome "understands theoretical underpinnings used for developing a science curriculum", identified in subsequent discussion as the construct *Theory*, was linked to the following indicators on the survey: articulate the key components of the science syllabus; provide a rationale based on theory for designing and implementing an effective science program; describe and analyse the theoretical base of science curriculum development; articulate constructivist principles for teaching science; compare existing approaches for teaching science; articulate different viewpoints on teaching science; and, talk comfortably about teaching science. The remaining constructs were identified as follows: *Children's Development* (Understanding of the development of children's concepts, abilities, skills, and attitudes); *Planning* (Understanding effective planning for science teaching and learning); and *Implementation* (Implementing effective science teaching practices). To substantiate the instrument's validity, four primary science teacher educators examined the items on the survey, which was similar to another instrument (Hudson & Ginns, 2005). Survey responses with missing or improbable values were deleted (Hittleman & Simon, 2002).

Descriptive statistics were derived using SPSS13. Data analysis included: frequencies of each survey item under each associated construct (outcome), mean scores (*M*), and standard deviations (*SD*, see Hittleman & Simon, 2002). Analysing individual items aimed to provide further insight into these constructs. Participants also commented on the advantages and disadvantages of the online science education course, the discussion forum, and ways to improve this online science education course. Responses were collated for similarities and reported after the statistical results.

Results and discussion

The following are key descriptors of the posttest sample (*n*=26; 23 female, 3 male) provided from the preservice teachers' responses on the first section of this survey (Appendix 1). Although 27% of these preservice teachers were less than 22 years of age and 31% were between 22 and 29 years of age, there were also 42% who were older than 30 years of age. Eighty-four percent had completed one or two science content course, and 11% had not completed a science course. In addition, 8% completed one practicum (field experience) and 89% indicated they had completed more than one practicum. Eighty-one percent claimed they had taught at least one science lesson in their field experiences. Only 11% indicated that science may be considered a strength at the conclusion of this course with 89% uncertain, disagreeing, or strongly disagreeing that science may be a strength.

Understanding the theory for developing a science curriculum (Construct – Theory)

The posttest results indicated that more than 88% of these preservice teachers generally agreed or strongly agreed that they believed they understood the *Theory* used for developing a primary science curriculum. Percentages of preservice teachers who responded agree and strongly agree for each associated indicator in the posttest are shown in Table 1. These percentages appeared to be relatively high in comparison with preservice teachers who have completed the same on-campus course at the same university (see Hudson & Ginns, 2005). An assessment task had criteria associated with these items, which encouraged the preservice teachers to have clear understandings of these concepts as a course requirement.

Table 1

Descriptive Statistics of Preservice Teachers' (n=26) Posttest Responses for the Construct "Theory"

Item	Indicator	*M*	*SD*	%*
1	Syllabus	4.23	0.59	92
3	Rationale	4.35	0.49	100
9	Theory	4.08	0.80	88
15	Constructivist	4.54	0.51	100
18	Teaching approaches	4.19	0.49	96
23	Viewpoints	4.15	0.54	92
33	Talking about science	4.23	0.51	96

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the theory for developing a science curriculum.

Understanding of the development of children's concepts, abilities, skills, and attitudes (Construct – Children's Development)

The second construct examined was the preservice teachers' perceptions of their understanding of the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes (*Children's Development*). Although posttest descriptive statistics revealed that 88% or more agreed or strongly agreed with three of the items (i.e., 2, 6, & 17), only 73% of these preservice teachers agreed or strongly agreed they understood the development of children's manipulative skills for learning science at the conclusion of this course (Table 2). Preservice teachers attending on-campus workshops can be exposed to manipulative skill development through hands-on experiences and face-to-face discussion with peers. The preservice teachers' online learning of science education in this study had not received hands-on experiences for understanding children's manipulative skill development. Online courses will continually advance methods for conveying primary students' manipulative skills to preservice teachers in ways that aim to substitute practical experiences.

Table 2

Descriptive Statistics of Preservice Teachers' (n=26) Posttest Responses for the Construct "Children's Development"

Item	Indicator	*M*	*SD*	%*
2	Scientific reasoning	4.35	0.56	96
6	Attitudes	4.15	0.61	88
17	Science concepts	4.23	0.65	88
28	Manipulative skills	3.96	0.82	73

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the development of children's science concepts, scientific reasoning abilities, manipulative skills, and attitudes.

Understanding effective planning for science teaching and learning (Construct – Planning)

The third construct examined preservice teachers' perceptions of their understandings for effective planning for science teaching and learning. Posttest statistics indicated that all these preservice teachers (*n*=26) agreed or strongly agreed that they could devise clear lesson plans for teaching science (Item 5), devise a scope and sequence plan (Item 7), program effectively for science teaching (Item 8), understand outcome-based education (Item 10), and integrate science across the curriculum (Item 14; Table 3). Although the lowest percentages were for affective domain (Item 12) and inclusivity (Item 26), these were both greater than 85% (Table 3). For these 26 preservice teachers, planning for science teaching and learning may not be a difficulty. Nevertheless, 68% of preservice teachers involved in the online course had not responded to this survey; hence these results need to be read with caution.

Table 3

Descriptive Statistics of Preservice Teachers' (n=26) Posttest Responses for the Construct "Planning"

Item	Indicator	*M*	*SD*	%*
5	Lesson plans	4.54	0.51	100
7	Scope and sequence	4.35	0.49	100
8	Program	4.42	0.50	100
10	Outcomes	4.50	0.51	100
12	Affective domain	4.04	0.53	88
14	Integrate	4.50	0.51	100
19	Appropriate activities	4.19	0.49	96
26	Inclusivity	4.15	0.61	87
29	Concept map	4.38	0.57	96

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood effective planning for science teaching and learning.

Implementing effective science teaching practices (Construct – Implementation)

Finally, the fourth construct involved determining these preservice teachers' perceptions of their understandings of implementing effective science teaching practices, including successful management of the learning environment. Posttest results indicated these third-year preservice teachers (*n*=26) had an understanding of implementing primary science education (percentage range: 84-100%) after completing this online science education course. Indeed, all these preservice teachers agreed or strongly agreed with five *Implementation* items (i.e., items 4, 11, 21, 30, & 31; Table 4).

Table 4

Descriptive Statistics of Preservice Teachers' (n=26) Posttest Responses for the Construct "Implementation"

Item	Indicator	*M*	*SD*	%*
4	Problem-based learning	4.38	0.50	100
11	Strategies	4.42	0.50	100
13	Classroom management	4.32	0.63	88
16	Learning environment	4.15	0.67	84
20	Ethical issues	3.96	0.45	88
21	Unit of work	4.50	0.51	100
22	Assessments	4.12	0.43	96
24	Critical reflection	4.27	0.53	96
25	Questioning skills	4.12	0.71	88
27	Evaluate	4.35	0.56	96
30	Positive attitudes	4.46	0.51	100
31	Hands-on lessons	4.54	0.51	100
32	Content knowledge	3.92	0.74	85
34	Teaching confidently	4.19	0.63	88

* Percentage of preservice teachers who "agreed" or "strongly agreed" that they believed they understood the implementation of effective science teaching practices, including successful management of the learning environment.

Once more, these relatively high percentages would need to be interpreted cautiously as there is a clear possibility that other preservice teachers who had not responded to this survey (68%) may include those who perceived themselves not being strong in one or more of these course constructs.

Qualitative evaluation of the online science education course

These preservice teachers (*n*=26) were asked to comment on the advantages and disadvantages of the online science education course, the discussion forum, and ways to improve this online course.

Perceived advantages for this online course

The preservice teachers (*n*=26) involved in this online science education course generally perceived flexibility of learning was the main advantage for completing online coursework. This flexibility included: (1) maintaining lifestyle and working arrangements, (2) catering for individual learning modes, (3) accessing web-based resources and assessment examples, and (4) open communication with staff and peers.

These science education preservice teachers claimed that the online units "offer flexibility", "self-paced learning" yet was "structured enough to encourage constant work". Indeed, as 73% of these surveyed participants were older than 22 years of age, the results indicated that flexible learning modes were required to maintain their lifestyles and working arrangements. For example, Participant 22 wrote, "I study at times suitable for my current lifestyle (i.e. 3:20 am)." The increased flexibility in learning how to teach primary science education can encourage and motivate preservice teachers to develop a greater understanding of key concepts. To illustrate, Participant 7 claimed, "The level of independent study forced me to pursue a high level of understanding of the unit concepts."

This flexible learning mode had ample online resources that could aid preservice teachers to complete assessment tasks. For example, Participant 15 wrote that the course website "provided samples and examples/proformas of what was expected", and another claimed the "hints and guidelines provided for portfolio assignment assisted the completion of the assessment tasks". The course's week-by-week guidelines were also well received, for example, "the practical plan regarding progression of studying e.g. setting out week by week what we can achieve helped me" (Participant 3).

Perceived disadvantages for online courses

Disadvantages perceived by the preservice teachers included the issue of self-discipline for completing the course requirements, uncertainty of ICT skills for completing assessment tasks, and the varied support from lecturers. Participant 19 wrote:

> There can be a tendency for students to lack self discipline required to maintain a steady progression through the course – so things like prac, other subject assignment loads, other outside study commitments and so on can impact on study routine and this means time spent on a subject can suffer.

As online coursework is largely an independent form of study, such independency may produce feelings of uncertainty, especially if participants are novice users of websites/Internet for independent study. To illustrate, "Despite study guidelines I was sometimes uncertain as to whether I was on the right track with regard to the assignment questions" (Participant 11). Even though participants appreciated the feedback from tutors (e.g., "Useful feedback on assignments from tutor" – Participant 24), others claimed that further support was necessary and there was "not as much support from lecturers. Email is easily misinterpreted" (Participant 17).

Addressing these concerns will require considerable thought as providing a structure to the course that ensures students are more self-disciplined may reduce the flexibility advantage between learning and lifestyle. Nevertheless, study guidelines need to be continually revised to provide further clarity of assignment criteria. Clearer guidelines need to be established for preservice teachers who require more support from lecturers, particularly if lecturers are unaware that such support was needed. Indeed, clear communication is a key for successful teaching and learning but structures need to be put in place to facilitate effective communication.

Whether online or face-to-face, effective communication is essential for learning. Preservice teachers need to have access to teaching staff and their peers so they can further develop conceptual understanding for teaching primary science. Online courses allow for open communication that may be accessed 24 hours a day, 7 days a week. One student claimed that the online course “kept lines of communication opened and ensured accessibility between staff and students” (Participant 8).

Discussion forums

Open communication was also facilitated through a discussion forum, in which five to six preservice teachers were placed in groups to discuss pertinent primary science teaching topics. Some discussion forum prompts in the form of questions and statements were provided to facilitate interaction (e.g., Analyse a science teaching strategy that would be inclusive for all students. Explain why it is inclusive. Discuss some questions you would use to reflect upon for evaluating either your teaching or the learning environment. What are effective science teaching strategies? How would these strategies make learning more fruitful?). These preservice teachers needed to write at least three discussion forum contributions as part of their assessment requirements (i.e., assessment value=20%).

Online courses can assist students to maintain their lifestyle while catering for their individual learning needs. The Internet can allow students to access resources and assessment examples at a time suitable. As learning is a social endeavour, open communication with staff and peers may further assist students to develop their teaching practices. One student summarised these flexible arrangements as follows:

> After having no real science experience since junior high, I feel this unit adequately provided me with the knowledge, experience and skills I need to teach science well. I enjoyed going at my own pace and the research involved. I liked being able to access the study material via the net when it was convenient to me. The feedback after the assignments was fast and appreciated (Participant 3).

There were mixed responses to the online discussion forum. Even though some claimed the forum allowed participants to understand the science education topics, for example, "The online discussion forum was great as it encouraged you to contribute and become very familiar with all the topics not just become engrossed in your own assignment" (Participant 22), others claimed it was confusing and mainly produced essay writing formats. To illustrate, Participant 4 stated the "discussion forum was confusing – hard not to write in essay format whilst trying to address all assessment requirements." An assessment criterion for the discussion forum included participants providing well-informed responses. This tended to reduce the effect of facilitating a discussion instead essay-style writing was dominant. One preservice teacher stated, "Having to reference everything limited the spontaneity of discussion and response, and put pressure on the contributions being written in essay form" (Participant 16).

Problems also arose with the varied frequency of responses by students. For example, one preservice teacher claimed there was "no discussion until the very last week even though I emailed group to prompt them into early discussions" (Participant 1). Another stated, "very little <u>discussion</u> took place and one student logged on for the discussion forum the day it was due" (Participant 8). The overall perception was that the discussion forums were generally unnecessary. To illustrate, "the use of discussion forums as compulsory, assessable things is a waste of time" (Participant 17). There appeared to be perceptions of inequity when having discussion forums as an assessable item. For example, "In this subject I didn't like being put into a group as my group didn't respond to any of my emails and only put in their responses when the assignment was due" (Participant 17).

There were two main problems with the discussion forum, namely: (1) the assessment criteria facilitated essay writing responses as a result of being asked to provide an informed contribution, and (2) less motivated students responded at the last moment, possibly as a result of having one set date for final contributions. These problems may be rectified by: (1) emphasising conversational language by providing a clear example of what is expected, and (2) establishing three set dates so students are contributing throughout the course and not just at the end.

Improvements to the science education course

An important aspect of developing coursework is the consideration of student evaluation. By asking students to suggest improvements to this science education course, revisions and enhancements may be made. Several students stated the science education course needed no improvement, to illustrate, "In my opinion nothing needs to be improved in this course. It was interesting and informative and has demonstrated to me that science can be fun" (Participant 11). However, suggestions for improvement involved: (1) further organisation of the course website, (2) addressing issues with the discussion forum, and (3) consideration of the assessment workload.

A clear, well structured website can more readily facilitate students' navigation of their learning for teaching primary science. For example, one preservice teacher claimed, "The links were great, but not very well tagged" (Participant 4). She suggested "perhaps the website could be organised with all links to the same topic under one heading." It appears that course websites should have no or little repetition of information as this may confuse students, for example, "I found the online site very difficult to follow. Some of the headings repeated the same information" (Participant 17). Another wrote that the effects on PowerPoint presentations were pointless, that is, "The PowerPoint presentations were a pain to go through with all the arty effects – we want substantial easily assessed information that we can find again easily" (Participant 24). Finally, using the *Notices* section on the webpage as part of regular support and direction from the lecturers/tutors was well received and provided a sound link between the tutors and preservice teachers, however, two claimed that this could be used more frequently (Participant 2 and 17).

As there were issues with the discussion forum, students willingly provided possible suggestions for improvement, including keeping the discussion forum as a non-assessable item, to illustrate:

> Maybe another forum of assessment for this 20% could be arranged and still have the discussion forum, as it is a good idea when used effectively, but not assess the contributions. (Participant 7)

Although support was provided by lecturers in the discussion forum, it may not have been sufficient enough to address preservice teachers' concerns. Participant 17 requested more support from lecturers, "Lecturer/tutor support need to be available through discussion forums so that students can have queries answered which often benefit other students." This participant also wrote that such support would allow "students to help and support each other."

Finally, the balance between workload and lifestyle continued as a theme throughout this evaluation, to illustrate:

> A huge workload – found all the info to sift through very overwhelming – but as I said it was worth it, and it could have been just me (e.g., other responsibilities in my life that caused me to feel this way)". (Participant 17)

Even though workloads were in keeping with university standards and expectations, students generally indicated that they learnt how to teach science from the online unit. For example, "I felt by the end of the unit much more confident to teach science than at the start. I learnt a lot" (Participant 22).

Conclusion

The statistical results need to be interpreted with caution as more than two thirds had not responded to this survey. Nevertheless, the results provided an indication that an online science education course can be used to develop preservice teachers' knowledge and skills for teaching primary science. Understanding children's manipulative skills for learning about science will require further refinement as an online medium. Indeed, further research into preservice teachers' understandings of children's manipulative skills need to be compared between online and on-campus courses. The qualitative comments provided insight on the advantages and disadvantages of the online science education course, the discussion forum, and ways to improve this online science education course. It appeared that preservice teachers appreciated the flexibility of working online as they can adjust their studies to fit in with their commitments and lifestyle. It was also evident that these preservice teachers were generally responsive to the online course and perceived considerable learning about teaching science education in the primary school.

Online education courses have advanced significantly, however, replacement or substitution for practical hands-on experiences will need to be overcome. Educators and website designers need to provide for greater understandings of primary students' manipulative skills and attitudes towards learning science. Although videos of classroom interactions may assist this process, there is also the issue of how to use the senses to the fullest in order to understand these skills and attitudes. A surgeon may learn intricate details for performing a heart transplant online, yet the feel, the smell, the sounds of operating are far more informative through hands-on experiences. Online learning is still in the formative stages (akin to advanced textbook learning) and needs to project to a higher level of learning associated with real hands-on experiences. Online preservice teacher education programs need to reflect the intentions of reform documents by assessing preservice teachers' abilities to implement reform measures. Studies on preservice teachers' real-life experiences after online learning of science teaching can provide insights for developing science education websites. The question remains: How can websites replace first-hand experiences for learning how to teach science effectively?

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Appendix 1

Primary Curriculum and Pedagogies: Science

SECTION 1: This section aims to find out some information about you in relation to your responses in Section 2. To preserve your anonymity, write your mother's maiden name on this survey. Please ***circle*** the answers that apply to you. Thank you for your participation.

Mother's maiden name:____

a) What is your sex? Male Female

b) What is your age? <22 yrs 22 - 29 yrs 30 - 39 yrs >40 yrs

c) What science courses did you complete in Years 11 and 12 at high school?

____

d) How many science curriculum/methodology courses have you completed at university so far?

0 1 2 3 4 or more

e) How many block practicums (field experiences have you now completed during your tertiary teacher education?

0 1 2 3 4 5 or more

f) How many primary science lessons have you taught so far?

0 1 2 3 4 5 6 or more

g) Would science be one of your strongest subjects?

Strongly disagree Disagree Uncertain Agree Strongly Agree

h) I would like to learn about teaching primary science in other educational systems?

Strongly disagree Disagree Uncertain Agree Strongly Agree

i) I would develop my primary science teaching by collaborating with university teacher education students from other countries?

Strongly disagree Disagree Uncertain Agree Strongly Agree

j) I believe I have the knowledge and skills in primary science teaching to interact effectively with university teacher education students from other countries?

Strongly disagree Disagree Uncertain Agree Strongly Agree

SECTION 2:

The following statements relate to your development towards becoming a teacher of primary science. Please indicate the degree to which you disagree or agree with each statement below by circling only <u>one</u> response to the right of each statement.

Key

SD = Strongly Disagree

D = Disagree

U = Uncertain

A = Agree

SA = Strongly Agree

In developing my understanding of primary curriculum and pedagogies towards becoming a teacher of primary science, I believe I can:

1. articulate the key components of the primary science syllabus. ………….	SD	D	U	A	SA
2. discuss the development of children's scientific reasoning abilities. …….	SD	D	U	A	SA
3. provide a rationale based on theory for designing and implementing an effective science program.	SD	D	U	A	SA
4. provide a problem-based learning environment for teaching primary science.	SD	D	U	A	SA
5. devise clear lesson structures for teaching primary science. ……………….	SD	D	U	A	SA
6. discuss the development of children's attitudes for learning primary science.	SD	D	U	A	SA
7. develop a scope and sequence for teaching primary science. ……………..	SD	D	U	A	SA
8. articulate the components of an effective primary science program. ………	SD	D	U	A	SA
9. describe and analyse the theoretical base of science curriculum development.	SD	D	U	A	SA
10. use an outcomes-based approach for planning, implementing, and assessing primary science education.	SD	D	U	A	SA
11. implement appropriate primary science teaching strategies. ………………	SD	D	U	A	SA
12. articulate the affective domains for teaching and learning primary science.	SD	D	U	A	SA

13. model effective classroom management when teaching science. ………… SD D U A SA

14. integrate primary science education with other key learning areas. ….….. SD D U A SA

15. articulate constructivist principles for teaching primary science. ………… SD D U A SA

16. manage the primary science learning environment effectively. ………….. SD D U A SA

17. discuss the development of children's science concepts. ………………… SD D U A SA

18. compare existing approaches for teaching primary science. ……………. SD D U A SA

19. select appropriate activities and resources for teaching primary science. SD D U A SA

20. address ethical and attitudinal issues related for implementing a primary science lesson.

SD D U A SA

21. design a primary science unit of work. …………………………………… SD D U A SA

22. assess the students' learning of primary science. ………………………… SD D U A SA

23. articulate different viewpoints on teaching primary science. ……………. SD D U A SA

24. critically reflect on becoming a more effective teacher of primary science. SD D U A SA

25. use effective questioning skills for teaching primary science. …………… SD D U A SA

26. provide primary science lessons that cater for all students regardless of ability (i.e., inclusivity).

SD D U A SA

27. critically evaluate my primary science teaching. …………………………. SD D U A SA

28. demonstrate an understanding of the development of children's manipulative skills for investigating science.

SD D U A SA

29. use concept maps for planning a primary science unit of work. …………..SD D U A SA

30. demonstrate positive attitudes towards teaching primary science. ……….. SD D U A SA

31. use hands-on materials for teaching primary science. ……………………. SD D U A SA

32. teach primary science with competent content knowledge. ……………….SD D U A SA

33. talk comfortably about teaching primary science. ……………………..… SD D U A SA

34. teach primary science confidently. ……………………………………… SD D U A SA